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DEVELOPMENT OF PNEUMATIC ROVING END OPENER

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ABSTRACT

In a textile mill, different textile wastes are generated in large amount and roving waste is among one of these. In the spinning process, slivers are drawn and twisted into roving by a roving frame. The roving is then wound around roving bobbins by a fly frame. The bobbins are sent to a ring spinning frame and then roving is unwound from the bobbins. During this process, some damaged roving remains on the bobbins as a waste. This roving can be recycled and reused by using roving end opener. The waste roving fibres are opened by using mechanical roving end opener in which beater is used to open the roving but during the opening of roving the fibers get damaged and its quality gets deteriorated. This paper is based on the concept of pneumatic roving end opener whose main advantage is that roving gets opened without damage to the fibres and it will operate on compressed air in mill premises and it requires less maintenance.

KEYWORDS: Roving Waste, Fibers, Recycling & ANSYS Fluent

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Original Article

1. INTRODUCTION

The waste produced in a textile mill is an important factor in determining the operating cost and therefore in influencing mill profits. The recovered fibers from waste can be used to produce blended yarns (waste/virgin fibers) in different proportions [1]. These fibers can be reused for the open end spinning and friction spinning but nowadays attempts on ring spinning are also in progress. The requirements of quality imposed on the finished products allow only the addition of tiny quantities of recovered fibers. This paper presents the method for recycling of roving waste. Sliver is a bundle of fibre made from cotton after passing through the various processes. The drawn sliver is fed into a machine called a roving frame, the final step before spinning. In the roving frame, the strands of the fibre are lengthened still further by a series of rollers. As the fibres are wound onto the bobbins they are twisted slightly, and this twisted strand is called the roving. The roving is shown in figure 1. The twist results in improved cohesion of the strand and condenses it so that the strand can be handled effectively in the subsequent spinning process

Figure 1: Waste Roving.

1.1. Preparation of Roving from Raw Cotton

Cotton fibres arrive at the cotton spinning mill in the form of cotton bales that are packed densely. At this stage, the cotton contains 1–15% impurities (e. g. dust, dirt, vegetable matter) which must be removed. In order to convert the raw cotton into fibres that are separated and aligned in a suitable manner for yarn production, the cotton passes through the following processing stages:

A. Opening and cleaning
B. Blending
C. Carding
D. Combing (optional)
E. Drawing
F. Roving

Stages A to C take place in the blowroom, so called because the cotton is transferred from stage to stage using pneumatic transport, i. e. it is blown from one machine to the next. The fibres that leave the blowroom are separated into individual fibres which can then be further processed for yarn production. These stages are briefly explained below [10].

1.1.1. Stages in Roving Formation

A) Opening and Cleaning

Figure 2 demonstrates the different operations that occur in the blowroom. The term ‘opening’ means the process where the high-density bale is broken down into large clumps or tufts of fibres; these tufts are subsequently further broken down into smaller tufts (‘tuftlets’). At this stage, the individual fibres are not separated. In modern production mills, numerous cotton bales are unwrapped and arranged in lines in the blowroom for the start of processing. The automatic bale opener, which consists of sets of opposing points or spikes, then works its way along a line of bales, plucking tufts from each bale. The tufts are then transported pneumatically to the next stage, which is the cleaning operation. At this stage, a ‘pre-mixing’ operation is also carried out in which bales of different cotton grades or even fibre types can be positioned in the bale lay-down to achieve a certain blended specification.

Natural fibres such as cotton will unavoidably contain impurities, for example, leaf, seed, waste and dust, which must be expelled if high-quality yarns are to be created. The opening and carding operations of the blowroom remove these impurities from the fibres [10].

B) Blending

Natural fibres such as cotton can have observable variations in properties, such as maturity, length, strength and elongation. To abstain from handling issues further downstream in the cotton factory, it is basic that fibres are all around mixed to create a homogeneous mass that should bring about a steady yarn quality (in terms of, for example, strength and evenness). Blending may also be used to reduce production costs, i. e. higher (more expensive) grades of cotton may be blended with lower (cheaper) grades of cotton to reduce raw material costs per kilogram. The blending of cotton with man-made fibres often takes place further downstream from the blowroom. Manufacturers may, for example, use cotton/polyester blends to create easy-care fabrics. Some mills, however, will carry out the blending of cotton and man-made fibres in the blowroom stages as it may lead to better blending.

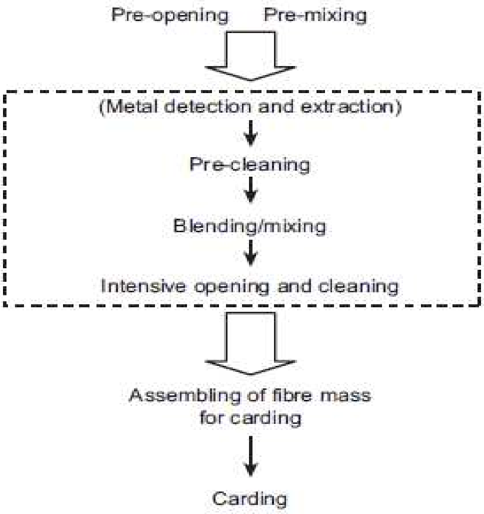

Figure 2: Blowroom Operations [10].

As the tufts arrive at each machine in the blowroom, they are collected in a hopper before being processed by the machine. As the tufts are collected, there is the opportunity for more mixing or blending to occur, so that tufts from different bales and different parts of the same bale can be mixed together to reduce any variations in quality [10].

C) Carding

The last stage in the blowroom process is carding. In this stage, the cleaned and mixed short tufts are converted into individual fibres. Fibre orientation is significant in carding. Fibres begin to be straightened and arranged in a common direction. These oriented fibres are then reassembled into a twistless rope of disentangled fibres held together by inter-fibre friction. This twistless rope is called a carded sliver and is coiled into large cans ready for use in the subsequent handling steps [10].

D) Combing

Combing is an optional step in fibre production and is used when a smoother, finer yarn is required. Fibres are subjected to further orientation by means of a comb-like device that arranges the fibres into an even stricter parallel form. The fibres are fed into the machine so that the edges of fibres can be combed by rotating pins. The combing process also expels short fibres (<0.5 in), fibre hooks and neps or impurities that might remain. Fibre hooks are fibres with hooked ends, created during the carding process as the fibres are moved along by the carding machinery; if not removed, they will result in the production of a weaker yarn. Combed yarns have a superior appearance compared to carded yarns, having smoother surfaces and finer diameters. The evacuation of short strands implies that less short closures appear on the outside of the texture, and the shine of the texture is additionally expanded. The additional processing stage means that combed yarns are more expensive to produce, and therefore fabrics made form combed yarns are higher in price. Because of this additional cost, most of cotton yarn is only carded, rather than carded and combed [10].

E) Drawing

Drawing includes the procedures of doubling and drafting. 'Doubling' refers to the fact, that several of the slivers formed during carding may be joined during drawing. 'Drafting' refers to the lengthening and straightening of the slivers. However, the terms 'drafting' and 'drawing' are often used interchangeably. Once more, mixing can happen at this stage, and in fact this is where cotton is generally mixed with a man-made fibre.

The carded sliver may contain up to 30,000 fibres in its cross-section. The function of the drawing process is to elongate the sliver to reduce the linear density to a level that is suitable for spinning (about 100 fibres in a cross-section). This lengthening is accomplished on a draw frame by a progression of rollers turning at various paces to create a solitary, uniform strand, which is then fed into large cans. This consistency is crucial to downstream production processes, for example, a thin area in a wide sliver could become a very thin and weak area in the final yarn. The drawing process also removes fibres with hooked ends from the carded sliver. The drawing process is repeated twice for carded slivers, while combed slivers are drawn once before combing and twice after combing hence the improved quality of fibres that have undergone both carding and combing operations [10].

F) Roving

A Roving is a long and thin bundle of fiber. Rovings are produced during the process of making spun yarn from fine quality raw cotton. In the wake of Carding and Combing, the fibres lie generally parallel in smooth groups. These are drawn out, by hand or machine, and a slight twist is given to form lengths suitable for spinning. It is made from 100% cotton process and used in spinning mills to make yarn [10].

2. LITERATURE SURVEY

Different mechanical processes have been used to shred and open the waste into fibers without affecting fiber length and blend it with virgin cotton [1]. The different waste produced in a textile mill is classified into different categories according to the stages in which it is generated. This waste can be mixed with cotton fibre according to the product desired [6]. The studies show that 25% of recovered fibre can be mixed with raw material without affecting the quality of yarn [1][5][7]. The use of air flow for the opening of roving results in no damage to the opened fibres [12].

3. PROCESSING OF ROVING WASTE

3.1. Generation of Roving Waste

In the spinning process, slivers are drawn and twisted into roving by a roving frame, then it is wound around roving bobbins by a fly frame. The bobbins are sent to a ring spinning frame where, the roving is unwound from the bobbins in this case the previous roving remain on the bobbins. The figure 3 shows the waste roving left on the bobbin. Roving waste is generated during the conversion of roving into yarn from speed frame machine to ring frame.

- During spinning operation when the roving is unbound from the roving bobbin some of the roving is left on the bobbin during processing.
- Another reason is damaged bobbin.

3.2. Mechanical Method of Opening Roving Waste

Existing methods like cutting the layers of roving with knives and opening them directly in the blow room lead to damage to the valuable bobbin surface and the fibres are subjected to fatigue which affects yarn quality. After the unbounding of roving that roving is recycled using mechanical roving end opener. This machine uses mechanical beater for opening the roving which is shown in figure 4. When the roving passes through beater it gets torn and fibres are separated, but during the passing of roving through the beater causes deterioration of fibers and its strength decreases, which is not acceptable because its quality decreases. This mechanical beater causes damage to fibres during recycling.

Figure 3: Waste Roving on Bobbin.

In mechanical roving end opener, these are the main parts which contribute to the opening of waste roving. The material flow for mechanical roving end opener is shown in figure 5.

- Feed roller
- Beater
- Perforated drum
- Delivery roller

Mechanical roving end opener requires two motors for its operation one motor for feed roller which feed the material into the machine and other for rotation of beater.

The waste processed by this machine has some disadvantages

- Damage of fibre during opening
- Requires power supply for its operation
- Jamming of beater during operation
- Maintenance is required periodically

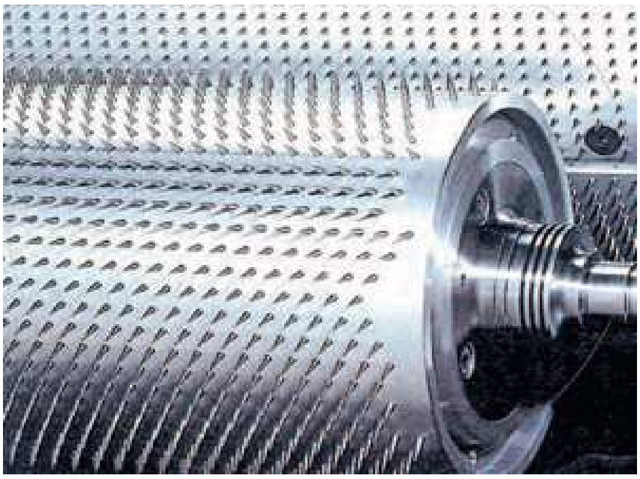

Figure 4: Mechanical Beater.

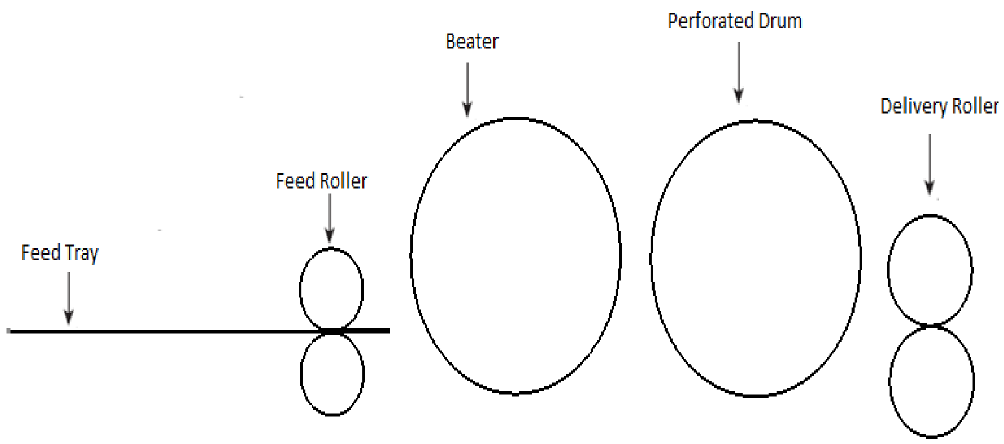

Figure 5: Material Flow of Mechanical Roving End Opener.

The above-mentioned problems associated with mechanical roving end opener is overcome by pneumatic roving end opener by using existing compressed air in the mill premises. This will help to improve the quality of fibers and reduce power consumption.

4. MODEL OF AIR OPERATED ROVING END OPENER

The conventional method of removing the roving from bobbin results into damage to bobbin. However, in pneumatic machine the roving is removed by rotary movement of the bobbins and simultaneously evacuating the roving by compressed air. The evacuated roving is thoroughly opened by nozzle applying compressed air current as a medium. This ensures that there is no physical damage to the fibre and bobbin as well. The roving can be effectively used as a fresh raw material without affecting yarn quality. The operation is more scientific and requires less labour. Like in a conventional machine the beater is used for the opening of roving here that task is done by a pneumatic nozzle.

The important parts of the machine are:

- Collection box
- Bobbin holder
- Roving bobbin
- Nozzle

4.1. Nozzle Design Calculation

This is the main part of this system because roving opening depends on the nozzle. In this system, the function of mechanical beater will be performed by a nozzle. To accelerate a fluid, we must use a converging nozzle at subsonic velocities and a diverging nozzle at supersonic velocities. The velocities encountered in most familiar applications are well below the sonic velocity, and thus it is natural that we visualize a nozzle as a converging duct. The air velocity required for opening of roving is 95 m/sec. The nozzle geometry is shown in figure 7.

The inlet and outlet diameter of the nozzle is calculated from the continuity equation. The volume flow rate is $2.98*10^{-4}$. The fluid is considered as incompressible flow the equation is given below

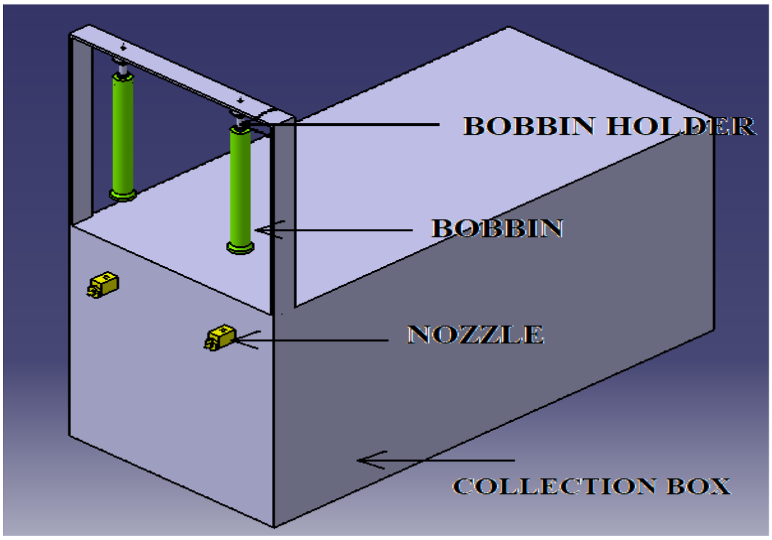

Figure 6: Model of Roving End Opener (Proposed).

$$Q = A * V \tag{1}$$

where,

Q = Discharge through the nozzle

A = Nozzle area

V = Velocity of nozzle

The calculated inlet and outlet diameters of the nozzle are 5 mm and 2 mm respectively. The length is considered as 15 mm. The pressure drop in the nozzle is calculated by Bernoulli's equation which is given below

$$p + \frac{1}{2}\rho v^2 + \gamma z = \text{constant} \tag{2}$$

p = Pressure = N/m^2

ρ = Density of air = 1.22 kg/m^3

g = Acceleration due to gravity = 9.81 m/sec^2

v = Velocity = m/sec

$\gamma = \rho * g$

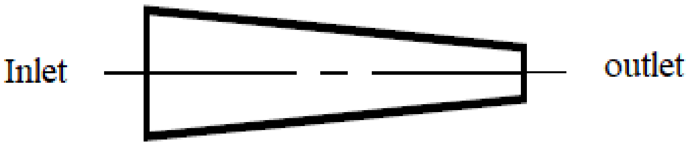

Figure 7: Geometry of Nozzle.

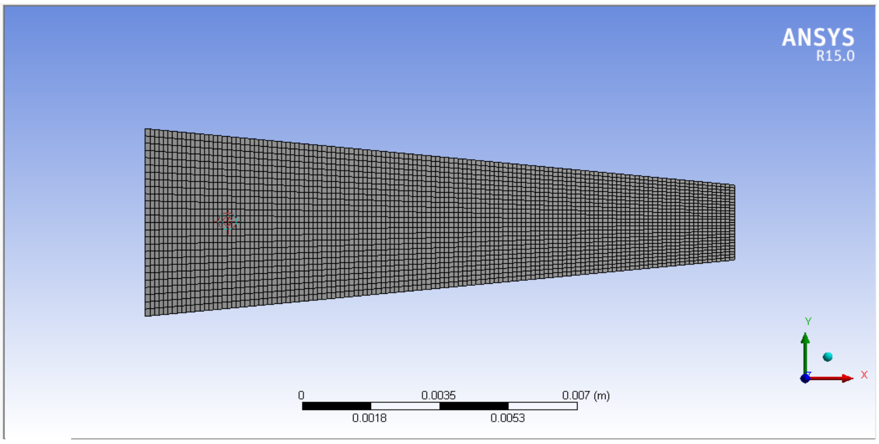

Figure 8: Representation of Convergent Nozzle Meshing.

The Bernoulli's equation is applied between the inlet and outlet of nozzle and pressure drop obtained along the length of the nozzle is 5364.31 N/m^2.

Advantages of air operated roving end opener:

- The gentle handle of fiber and reuse of valuable raw material.
- No bobbin damages during unwinding of roving.
- No electricity requirement.
- Eliminates the time wastages to unwind the bobbin.

4.2. CFD Results of Convergent Nozzle

CFD is a tool which is used to convert the partial differential equations into algebraic equations. With the advancement of computers solving complex flow problems made easy. Results obtained by the analysis are more accurate and reduces the time for solving. The analysis is done on ANSYS Fluent and the 2-dimensional modelling of the nozzle is done in ANSYS. The mesh created is of quad elements and it is mapped which is shown in figure 8. Pressure based solver is used and air (fluid) is considered as an ideal gas. Pressure inlet is defined as a boundary condition with a value of 5364.31 N/m^2 and the solution is initialized from the inlet velocity result is represented in figure 9 the velocity is minimum at the inlet of nozzle and increases towards the exit of nozzle. The minimum velocity is at the nozzle wall and maximum at the exit of the nozzle 95.7 m/sec is nearly the same value which is calculated by using the above equations (1) and (2).

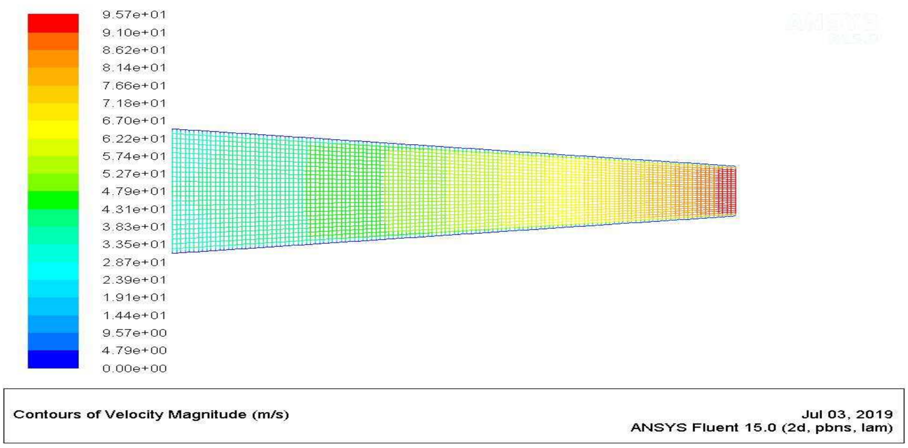

Figure 9: Representation of Convergent Nozzle Velocity Contour.

5. CONCLUSIONS

There is no fibre damage during the opening of waste roving and it saves energy as it is operated on compressed air available in a mill. About 15-20% of recycled fiber can be mixed with fresh cotton which can be used to produce yarn without affecting the quality of yarn. The blending of recycled fibre with raw cotton reduces the cost of raw cotton.

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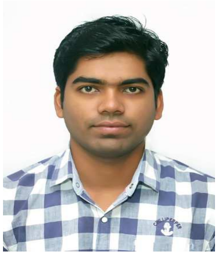

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